

# *Long-term Impacts of Diameter Caps*

on Douglas-fir/western  
hemlock forests

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# Overview

- Controversial opinions
- Forest type of interest
- An optimization model
- Consequences and implications

# Upper size limits on harvests



## SUPPORTIVE

Preservation, ecological value, fire

## NEUTRAL

## OPPOSED

Openings, densities, economics

# Previous studies

Forest type: Ponderosa pines

Study area: Southwest (CA, AZ)

Caps: 16 inches

*(Larson and Mirth 2001, Coughlan 2003, Abella et al. 2006)*

- Negative effect on economics
- High densities of large trees benefit some, while impair others
- Limit short-term timber production, increase stock in long term

## Shade intolerant

65%

**Douglas-fir** *Pseudotsuga menziesii* 41%

**Red alder** *Alnus rubra* 11%

**Ponderosa pine** *Pinus ponderosa* 7%

## Shade tolerant

35%

**Western hemlock** *Tsuga heterophylla* 19%

**Western red cedar** *Thuja plicata* 6%

**Bigleaf maple** *Acer macrophyllum* 3%



# Sample plots (PNW-FIA)





Northern spotted owls  
*(Strix Occidentalis Caurina)*

Late-seral stage



# Define a forest state

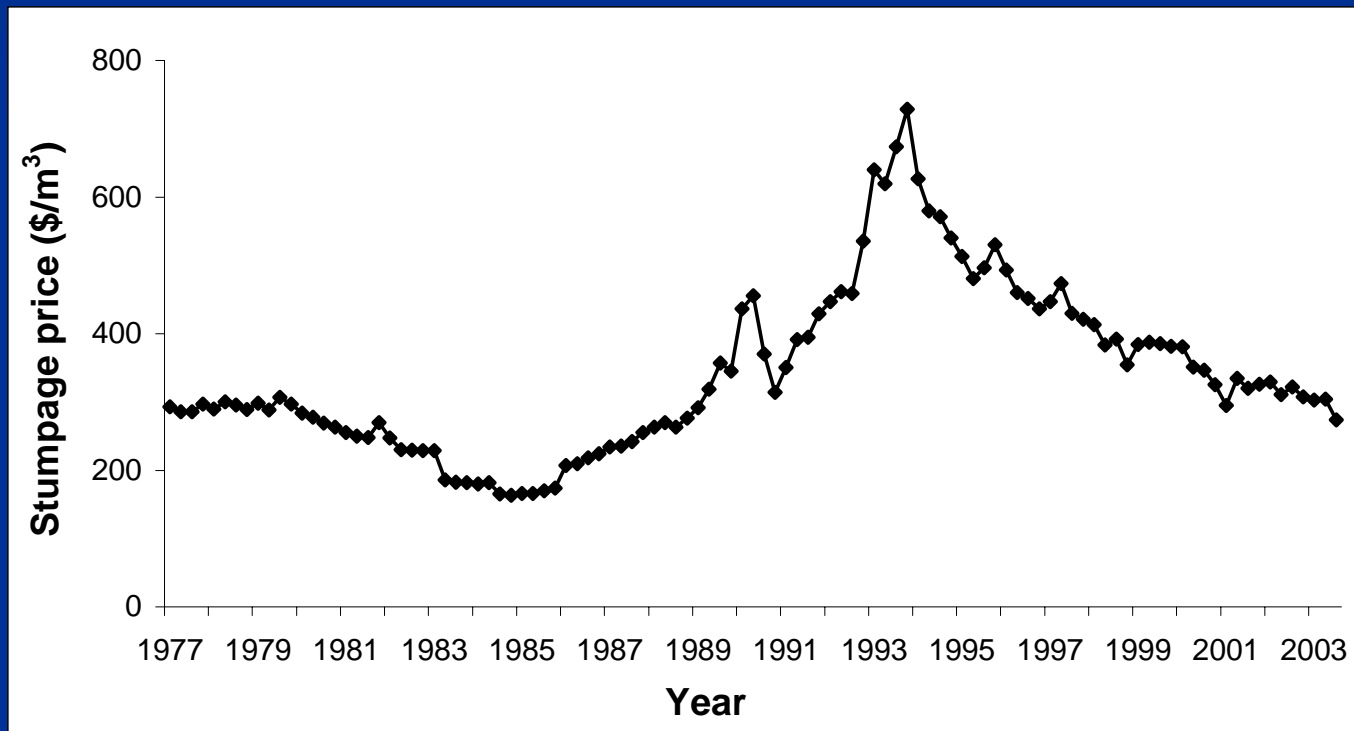
	Shade-intolerant			Shade-tolerant		
<b>DBH</b> (cm)	small 10- 25	medium 25 - 41	large $\geq 41$	small 10 - 25	medium 25 - 41	large $\geq 41$
<b>Threshold</b> (m <sup>2</sup> /ha)	5.85	5.37	5.39	3.25	2.48	2.84



# Forest growth in a year

		Year $t+1$					
Year $t$	000,000	000,001	000,010	...	111,101	111,110	111,111
000,000	0.79	0	0.01	...	0	0	0
000,001	0.78	0	0	...	0	0	0
000,010	0.02	0	0.80	...	0	0	0
...	...	...	...	...	...	...	...
111,101	0	0	0	...	0.87	0.00	0.02
111,110	0	0	0	...	0	0.85	0.04
111,111	0	0	0	...	0.02	0	0.88

# Price movements



# Price change in a year

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	Price level at $t+1$ year		
Price level at $t$	Low	Medium	High
Low ( $\leq 539.4$ \$ m <sup>-3</sup> )	0.928	0.067	0.004
Medium ( $> 539.4$ \$ m <sup>-3</sup> , $\leq 824.1$ \$ m <sup>3</sup> )	0.072	0.866	0.062
High ( $> 824.1$ \$ m <sup>-3</sup> )	0.004	0.057	0.939

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# Optimization

- Objective: Max NPV
- Policy: no caps, 41 cm (16 in.) caps
- Criteria:
  - Economic: NPV, annual harvest
  - Ecological: BA of large trees
    - late-seral forest
    - owl nesting habitat

# Optimization for NPV

## Effects on expected value of

	Cutting cycle (year)	NPV (\$/ha)	Annual harvest (m <sub>3</sub> /ha)	BA 41 cm (m <sub>2</sub> /ha)	Late- seral forest (%)	Owl nesting habitat (%)
41 cm caps	8.7	13,201	1.4	51.8	48.1	38.3
No caps	5.3	24,988	2.9	16.8	0.4	0
Current				31.3	5.4	4.5

# Forest composition

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16 in. caps	(%)	No caps	(%)
001,001	87.3	000,000	47.6
001,101	3.8	001,000	10.6
101,001	3.1	100,000	6.7
001,011	2.2	000,100	6.2
011,001	1.7	101,011	5.5

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# Loss of timber income

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	Percent (%)	Annual income (\$/ha/y)	NPV (\$/ha)
XX1,XX1	61 - 76	798 - 816	21,011 - 21463
XX1,XX0	46 - 66	514 - 531	13,523 – 13,975
XX0, XX1	37 - 54	416 - 419	10,943 – 11,025
XX0,XX0	11 - 13	61 - 89	1,553 – 2,342

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# Summary

- Opportunity cost ca. 12,000 \$/ha
- Loss of \$60 (lowest stock) to \$800 (highest stock) annually
- Ecologically beneficial in terms of late-seral stage and nesting habitat for spotted owls



# Implications

- Not sustainable by itself
- Sustainable with uneven-aged management



**Thank you!**

# Supplementary material

## Table 1. Structural definitions of late-seral forest and nesting habitat

### Late-seral forest

Basal area (BA) at least 55.2 m<sup>2</sup>/ha

BA trees greater than 61.0 cm dbh  $\geq$  8.3 m<sup>2</sup>/ha

BA trees greater than 35.6 cm dbh  $\geq$  33.1 m<sup>2</sup>/ha

BA trees less than 35.6 cm dbh  $\geq$  8.3 m<sup>2</sup>/ha

### Nesting habitat

BA at least 55.2 m<sup>2</sup>/ha

BA trees greater than 61.0 cm dbh  $\geq$  13.8 m<sup>2</sup>/ha

BA trees greater than 35.6 cm dbh  $\geq$  33.1 m<sup>2</sup>/ha

BA trees less than 35.6 cm dbh  $\geq$  11.0 m<sup>2</sup>/ha

BA Douglas-fir trees greater than 61.0 cm dbh  $\geq$  1.2 m<sup>2</sup>/ha

State	Basal area level by tree species and size	Frequency of FIA plots in this state	Expected total volume (m <sup>3</sup> /ha)	Expected total basal area (m <sup>2</sup> /ha)	Expected basal area of large trees (m <sup>2</sup> /ha)	Probability of:	
						Late seral forest	Owl-nesting habitat <sup>b</sup>
1	000000 <sup>a</sup>	0.066	3.8	18.2	7.9	0.000	0.000
2	000001	0.002	15.3	50.4	46.0	0.010	0.000
3	000010	0.011	7.1	28.7	14.5	0.000	0.000
4	000011	0.011	15.1	50.2	37.6	0.056	0.000
5	000100	0.031	4.4	20.9	8.7	0.000	0.000
6	000101	0.002	16.5	54.0	46.0	0.006	0.000
7	000110	0.025	7.3	30.3	14.9	0.000	0.000
8	000111	0.027	16.1	53.7	35.4	0.024	0.001
9	001000	0.004	15.2	49.3	35.7	0.000	0.000
10	001001	0.024	20.9	63.6	52.3	0.520	0.406
11	001010	0.003	15.1	49.8	31.8	0.000	0.000
12	001011	0.021	20.7	63.5	48.3	0.825	0.539
13	001100	0.004	16.1	52.2	35.6	0.000	0.000
14	001101	0.024	21.6	65.0	52.0	0.178	0.303
15	001110	0.005	16.0	52.3	36.7	0.000	0.000
16	001111	0.043	20.8	63.9	46.9	0.137	0.183

Stand	Decision when price is:				Stand	Decision when price is:			
state #	Low	Medium	High	Probability	state #	Low	Medium	High	Probability
1	-	-	-	0.000	33	1	1	1	0.000
2	-	-	-	0.007	34	-	2	2	0.001
3	1	1	1	0.000	35	1	1	1	0.000
4	2	2	2	0.000	36	34	2	2	0.000
5	1	1	1	0.000	37	-	1	1	0.000
6	2	2	2	0.001	38	34	2	2	0.000
7	1	1	1	0.000	39	37	1	1	0.000
8	2	2	2	0.000	40	34	2	2	0.000
9	-	-	-	0.004	41	-	9	9	0.000
10	-	-	-	0.873	42	10	10	10	0.031
11	9	9	9	0.000	43	41	9	9	0.000
12	10	10	10	0.022	44	10	10	10	0.000
13	-	9	9	0.000	45	13	9	9	0.000
14	10	10	10	0.038	46	10	10	10	0.002
15	13	9	9	0.000	47	13	9	9	0.000
16	10	10	10	0.001	48	10	10	10	0.000

\* 16 in. caps

Stand state #	Decision <sup>a</sup> when price is:				Stand state #	Decision when price is:			
	Low	Medium	High	Probability		Low	Medium	High	Probability
1	-	-	-	0.476	33	1	1	1	0.067
2	-	-	1	0.023	34	2	2	1	0.001
3	-	-	1	0.049	35	-	3	1	0.005
4	2	2	1	0.002	36	2	2	1	0.000
5	-	1	1	0.062	37	-	1	1	0.006
6	2	2	1	0.002	38	2	2	1	0.000
7	3	3	1	0.006	39	35	3	1	0.001
8	2	2	1	0.000	40	2	2	1	0.000
9	-	-	1	0.106	41	-	-	1	0.055
10	9	9	1	0.006	42	41	41	1	0.006
11	-	9	1	0.018	43	41	41	1	0.003
12	11	9	1	0.002	44	41	41	1	0.000
13	9	9	1	0.004	45	41	41	1	0.003
14	9	9	1	0.000	46	41	41	1	0.000
15	-	9	1	0.005	47	41	41	1	0.000
16	15	9	1	0.000	48	41	41	1	0.000

\* No caps